

The Future of **FOOD** natgeofood.com

By 2050 we'll need to feed two billion more people.
This special eight-month series explores how we can
do that — without overwhelming the planet.

Where will we
find enough food
for 9 billion?

*It doesn't have to be industrial
farms versus small, organic ones.
There's another way.*

A Five-Step Plan to Feed the World

By Jonathan Foley

Photographs by George Steinmetz and Jim Richardson



On the Vulgamore farm near Scott City, Kansas, each combine can harvest up to 25 acres of wheat an hour—as well as real-time data on crop yields. Most of the food Americans eat is now produced on such large-scale, mechanized farms, which grow row after row of a single crop, allowing farmers to cover more ground with less labor.

GEORGE STEINMETZ





At Granja Mantiqueira in Brazil eight million hens lay 5.4 million eggs a day. Conveyor belts whisk the eggs to a packaging facility. Demand for meat has tripled in the developing world in four decades, while egg consumption has increased sevenfold, driving a huge expansion of large-scale animal operations.

GEORGE STENMETZ



A bumper crop of corn piles up outside full silos in Brazil's Mato Grosso state, which sends much of its grain to China and South Korea to feed their pigs and chickens. The demand for more crops to feed livestock is one reason experts say we'll need to double crop production by 2050.

GEORGE STEINMETZ







When we think about threats to the environment, we tend to picture cars and smokestacks, not dinner. But the truth is, our need for food poses one of the biggest dangers to the planet.

Agriculture is among the greatest contributors to global warming, emitting more greenhouse gases than all our cars, trucks, trains, and airplanes combined—largely from methane released by cattle and rice farms, nitrous oxide from fertilized fields, and carbon dioxide from the cutting of rain forests to grow crops or raise livestock. Farming is the thirstiest user of our precious water supplies and a major polluter, as runoff from fertilizers and manure disrupts fragile lakes, rivers, and coastal ecosystems across the globe. Agriculture also accelerates the loss of biodiversity. As we've cleared areas of grassland and forest for farms, we've lost crucial habitat, making agriculture a major driver of wildlife extinction.

The environmental challenges posed by agriculture are huge, and they'll only become more pressing as we try to meet the growing need for food worldwide. We'll likely have two billion

more mouths to feed by mid-century—more than nine billion people. But sheer population growth isn't the only reason we'll need more food. The spread of prosperity across the world, especially in China and India, is driving an increased demand for meat, eggs, and dairy, boosting pressure to grow more corn and soybeans to feed more cattle, pigs, and chickens. If these trends continue, the double whammy of population growth and richer diets will require us to roughly double the amount of crops we grow by 2050.

Unfortunately the debate over how to address the global food challenge has become polarized, pitting conventional agriculture and global commerce against local food systems and organic farms. The arguments can be fierce, and like our politics, we seem to be getting more divided rather than finding common ground. Those who favor conventional agriculture talk about how

High in the Peruvian Andes, Estela Cóndor grows five different varieties of potatoes to sell in the market, along with a yellow tuber called *mashua* that she cooks for her family. Small farmers like Cóndor grow much of the food for people in the developing world.

JIM RICHARDSON



Mali

Bassama Camara, Sibly



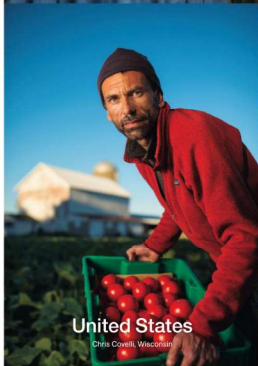
Ukraine

Olexandra Salo, Hlynske



Bangladesh

Anwara Begum, Sajali



United States

Chris Covelli, Wisconsin



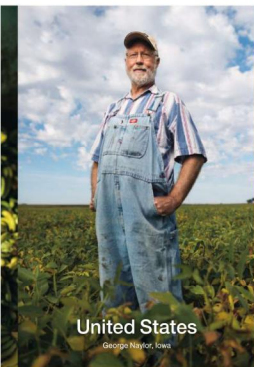
Ukraine

Valentin Tarasov, Starovyshnivetake



Indonesia

Pak Kompiang, Bali



United States

George Naylor, Iowa



Ethiopia

Girma Wodajo, Tulu Per



United Kingdom

Paul McGinnis, Isle of Skye



United States

Sally Gran, Iowa



Mali

Sékou Camara, Siky



United States

Frank Reese, Kansas

JIM RICHARDSON/ULLI



Industrial-size farms achieve high yields using fertilizer and pesticides to grow huge fields of one crop.



Though small farms tend to lag behind, they often deliver more food that actu



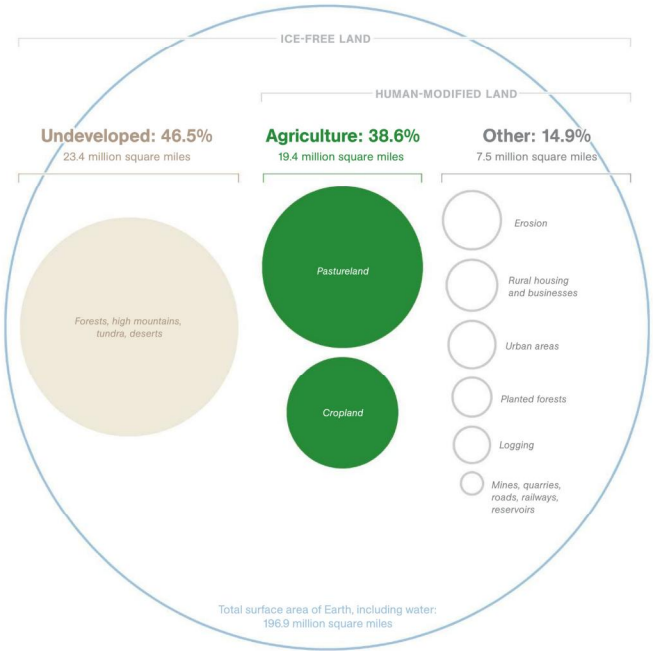
esh

*and industrial farms in yields,
ally ends up feeding people.*

JAM RICHARDSON (BOT-6)

Agriculture's Footprint

Farming of both livestock and crops is the largest human endeavor on Earth, using more than 38 percent of ice-free land. Our next largest impact: erosion caused by agriculture, building, logging, and mining.



ALL GRAPHICS AND MAP BY VIRGINIA W. MASON AND JASON TREAT, NGM STAFF. SOURCE: ROGER LEB, HOOKE, UNIVERSITY OF MAINE

modern mechanization, irrigation, fertilizers, and improved genetics can increase yields to help meet demand. And they're right. Meanwhile proponents of local and organic farms counter that the world's small farmers could increase yields plenty—and help themselves out of poverty—by adopting techniques that improve fertility without synthetic fertilizers and pesticides. They're right too.

But it needn't be an either-or proposition. Both approaches offer badly needed solutions; neither one alone gets us there. We would be wise to explore all of the good ideas, whether from organic and local farms or high-tech and conventional farms, and blend the best of both.

I was fortunate to lead a team of scientists who confronted this simple question: How can the world double the availability of food while simultaneously cutting the environmental harm caused by agriculture? After analyzing reams of data on agriculture and the environment, we proposed five steps that could solve the world's food dilemma.

STEP ONE *Freeze agriculture's footprint*

For most of history, whenever we've needed to produce more food, we've simply cut down forests or plowed grasslands to make more farms. We've already cleared an area roughly the size of South America to grow crops. To raise livestock, we've taken over even more land, an area roughly the size of Africa. Agriculture's footprint has caused the loss of whole ecosystems around the globe, including the prairies of North America and the Atlantic forest of Brazil, and tropical forests continue to be cleared at alarming rates. But we can no longer afford to increase food production through agricultural expansion. Trading tropical forest for farmland is one of the most destructive things we do to

the environment, and it is rarely done to benefit the 850 million people in the world who are still hungry. Most of the land cleared for agriculture in the tropics does not contribute much to the world's food security but is instead used to produce cattle, soybeans for livestock, timber, and palm oil. Avoiding further deforestation must be a top priority.

STEP TWO *Grow more on farms we've got*

Starting in the 1960s, the green revolution increased yields in Asia and Latin America using better crop varieties and more fertilizer, irrigation, and machines—but with major environmental costs. The world can now turn its attention to increasing yields on less productive farmlands—especially in Africa, Latin America, and eastern Europe—where there are “yield gaps” between current production levels and those possible with improved farming practices. Using high-tech, precision farming systems, as well as approaches borrowed from organic farming, we could boost yields in these places several times over.

STEP THREE *Use resources more efficiently*

We already have ways to achieve high yields while also dramatically reducing the environmental impacts of conventional farming. The green revolution relied on the intensive—and unsustainable—use of water and fossil-fuel-based chemicals. But commercial farming has started to make huge strides, finding innovative ways to better target the application of fertilizers and pesticides by using computerized tractors equipped with advanced sensors and GPS. Many growers apply customized blends of fertilizer tailored to their exact soil conditions, which helps minimize the runoff of chemicals into nearby waterways.

Organic farming can also greatly reduce the use of water and chemicals—by incorporating cover crops, mulches, and compost to improve soil quality, conserve water, and build up nutrients. Many farmers have also gotten smarter about water, replacing inefficient irrigation systems with more precise methods, like subsurface drip irrigation. Advances in both conventional

Jonathan Foley directs the Institute on the Environment at the University of Minnesota. Jim Richardson's portraits of farmers are the latest in his body of work documenting agriculture. George Steinmetz's big-picture approach reveals the landscapes of industrial food.



A World Demanding More

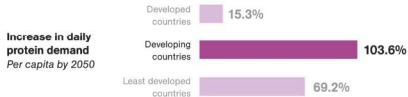
By 2050 the world's population will likely increase by about **35 percent**.



To feed that population, crop production will need to **double**.



Why? Production will have to far outpace population growth as the developing world grows prosperous enough to eat more meat.



SOURCE: DAVID TILMAN, UNIVERSITY OF MINNESOTA

and organic farming can give us more “crop per drop” from our water and nutrients.

STEP FOUR *Shift diets*

It would be far easier to feed nine billion people by 2050 if more of the crops we grew ended up in human stomachs. Today only 55 percent of the world's crop calories feed people directly; the rest are fed to livestock (about 36 percent) or turned into biofuels and industrial products (roughly 9 percent). Though many of us consume meat, dairy, and eggs from animals raised on feedlots, only a fraction of the calories in feed given to livestock make their way into the meat and milk that we consume. For every 100 calories of grain we feed animals, we get only about 40 new calories of milk, 22 calories of eggs, 12 of chicken, 10 of pork, or 3 of beef. Finding more efficient ways

to grow meat and shifting to less meat-intensive diets—even just switching from grain-fed beef to meats like chicken, pork, or pasture-raised beef—could free up substantial amounts of food across the world. Because people in developing countries are unlikely to eat less meat in the near future, given their newfound prosperity, we can first focus on countries that already have meat-rich diets. Curtailing the use of food crops for biofuels could also go a long way toward enhancing food availability.

STEP FIVE *Reduce waste*

An estimated 25 percent of the world's food calories and up to 50 percent of total food weight are lost or wasted before they can be consumed. In rich countries most of that waste occurs in homes, restaurants, or supermarkets. In poor

Mariam Kéita harvests peanuts on a farm in Siby, Mali. The green revolution's mix of hybrid seeds, fertilizers, and irrigation never took off in Africa. But sub-Saharan countries now offer a key opportunity to boost global food production, because their yields can be vastly improved.

JIM RICHARDSON

countries food is often lost between the farmer and the market, due to unreliable storage and transportation. Consumers in the developed world could reduce waste by taking such simple steps as serving smaller portions, eating leftovers, and encouraging cafeterias, restaurants, and supermarkets to develop waste-reducing measures. Of all of the options for boosting food availability, tackling waste would be one of the most effective.

TAKEN TOGETHER, these five steps could more than double the world's food supplies and dramatically cut the environmental impact of agriculture worldwide. But it won't be easy. These solutions require a big shift in thinking. For most of our history we have been blinded by the overzealous imperative of more, more, more in agriculture—clearing more land, growing more crops, using more resources. We need to find a balance between producing more food and sustaining the planet for future generations.

This is a pivotal moment when we face unprecedented challenges to food security and the preservation of our global environment. The good news is that we already know what we have to do; we just need to figure out how to do it. Addressing our global food challenges demands that all of us become more thoughtful about the food we put on our plates. We need to make connections between our food and the farmers who grow it, and between our food and the land, watersheds, and climate that sustain us. As we steer our grocery carts down the aisles of our supermarkets, the choices we make will help decide the future. □

The Future of Food

COMING IN JUNE

We already eat more farmed fish than beef...

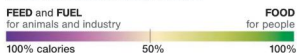
Can the
"blue revolution"
solve the world's
food puzzle?

ON THE WEB

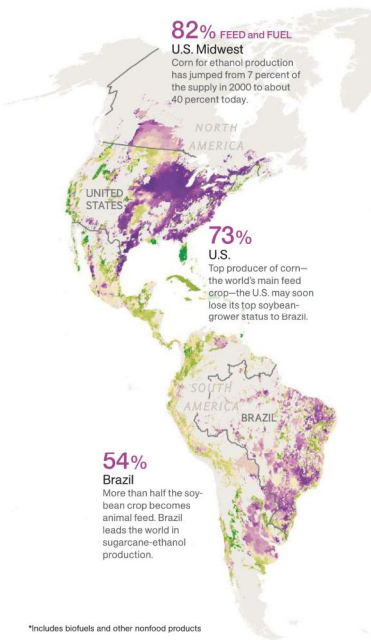
Join the conversation at natgeofood.com and get daily food news, videos, informed blogs, interactive graphics, bonus photos, and food facts of the day.

The magazine thanks The Rockefeller Foundation and members of the National Geographic Society for their generous support of this series of articles.

Where the calories are produced



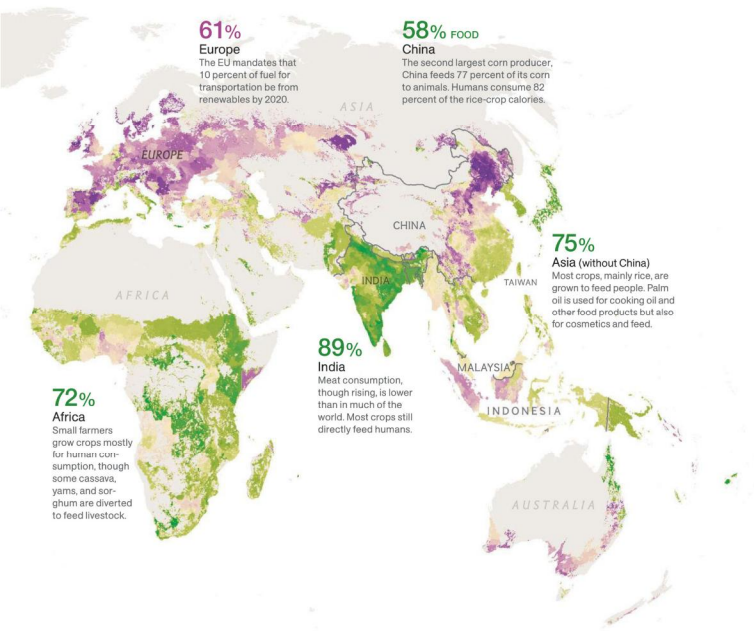
How global crop calories are used



SOURCE: GLOBAL LANDSCAPES INITIATIVE, INSTITUTE ON THE ENVIRONMENT, UNIVERSITY OF MINNESOTA

Food Versus Feed and Fuel

Percentages on the map show whether most of the calories in a region's crops go directly to human consumption (green) or go to animal feed and biofuels (purple). Only 55 percent of the world's food-crop calories directly nourish people. We get another 4 percent indirectly by eating meat, dairy, or eggs from animals raised on feed.



Only the Brazil nut trees—protected by national law—were left standing after farmers cleared this parcel of Amazon rain forest to grow corn. Despite progress in slowing deforestation, this northern state of Pará saw a worrying 37 percent spike over the past year.

GEORGE STEINMETZ







At the Nutribas pig farm in Brazil sows are confined to sectioned crates that allow a mother to suckle her piglets without accidentally crushing them. Hog farms can be big polluters—the average 200-pound pig produces 13 pounds of manure a day—but Nutribas recycles waste as fertilizer and methane power.

GEORGE STEINMETZ



On the Bassetti farm near Greenfield, California, workers harvest celery to be shipped to retail outlets in the U.S. and Asia. Dubbed "America's salad bowl," the Salinas Valley relies on ground-water for irrigation, which could be at risk if the current drought continues.

GEORGE STEINMETZ







Each month some 4.5 million chickens are killed, plucked, cut, trimmed, and packaged at this plant near Sidrolândia, Brazil. Their parts will travel the globe: Wings and feet go mostly to China, legs to Japan, and breasts to Europe. The global appetite for chicken means that production of poultry is growing much faster than that of either pork or beef.

GEORGE STEINMETZ





At Monsanto's North Carolina lab, corn plants emerge from an automated photo booth that documents their growth. The company is trying to develop strains of corn and soybeans that need less water and fertilizer—a goal that's eluded biotech thus far. Reducing the use of such resources is key to feeding the world in the coming decades.

GEORGE STEINMETZ



Beyond Delicious

You might say the apple fell from grace in the 1920s and '30s with the advent of refrigerated long-distance shipping. Thanks to supermarket Darwinism, thousands of heirloom varieties, like many of those at right, went commercially extinct. Produce bins featured Delicious, Jonathan, and Rome—selected for durability and beauty, but boring in taste. “People switched off their tastebuds,” says Diane Miller, an apple geneticist at Ohio State University. Apple consciousness-raising, says Miller, came with the release of the aptly named Honeycrisp hybrid in 1991. Now breeders create dozens of flavorful new hybrids a year and heirlooms are back in style.

Benton Red

Scott Winter

Westfield
Seek No FurtherEsopus
Spitzenburg

Zabergau

Empire

Twenty Ounce

Rhode Island Greening

Beauties of Wellington Benton
Oxford Blue Pear Collingwood
Nine Ounce Golden Russet
Garden Sweet Gravenstein
of Tompkins County
Opalescent Pomona
Island Greening
Scott Winter Somerset
Sweet Twenty Ounce
Further Winter Banana Winter



Wagener

Roxbury Russet

Cox's Orange Pippin

Winter Banana

Wolf River

Starkey

Magog Redstreak

Bramley's Seedling

Tolman Sweet

Gray Pearmain

Ribston Pippin

Stark

Golden Russet

Opalescent

Calville Blanc d'Hiver

Rolfe

Nodhead

Pomme Gris

Blue Pearmain

Deane
(Nine Ounce)

Pound Sweet